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UNITED STATES
DEPARTMENT OF THE INTERIOR
J. A. KRUG, SECRETARY

BUREAU OF MINES
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INFORMATION CIRCULAR

INSTALLATION OF A MODEL MAN CAGE AT THE AVOCA SHAFT OF THE HEIDELBERG COAL CO. AVOCA, LUZERNE COUNTY, PA.

BY

E. H. McCLEARY AND JOSEPH V. MATHER

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INSTALLATION OF A MODEL MAN CAGE AT THE AVOCA SHAFT OF THE HEIDELBERG COAL CO., AVOCA, LUZERNE COUNTY, PA.[1]

By E. H. McCleary[2] and Joseph V. Mather[3]

INTRODUCTION

Workmen are transported in shafts in various types of cages or skips, most of which were designed primarily for hoisting cars and materials. Therefore, in general the cages or skips are not completely enclosed, adequate end gates are not always provided, and at many mines signaling devices and telephones are restricted to those at the various landings in the shafts.

Shaft accidents are usually severe - frequently fatal - and as a rule such an accident is caused by failure to comply with company rules or by ignoring them.

Sixty men were killed and 555 men were injured in shafts of the anthracite and bituminous coal mines of the United States during the 5-year period 1938-42.[4] Many of these accidents could have been prevented by having properly enclosed cages and adequate locking devices on doors to prevent workmen from falling into the shafts.

The officials of the Heidelberg Coal Co. contemplated utilizing an old coal-hoisting shaft as a man-hoisting shaft; however, it was their desire to avoid the use of the conventional cage and to try to provide a safer means of transporting men in the shaft. Investigations and studies made by the officials revealed that an elevator similar to those used in large buildings would be more economical in first cost, maintenance, and operating costs would be less, and it would be safer and more convenient for the workmen. Effective safety devices for such elevators have been developed to such a high degree that those properly installed seldom fail. The elevator or man cage finally chosen cannot be pulled above the top landing through mechanical or man failure; it stops automatically at each landing and cannot be moved while a door is open; when the cage leaves the landing the doors opening to the shaft are automatically locked by mechanical and electrically operated locks; electric lights, telephone communication, and push-bottom controls are available on the cage, and adequate safety switches and overspeed controls are provided.

1/ The Bureau of Mines will welcome reprinting of this paper provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7407."

2/ Supervising engineer.

3/ Mining explosives engineer.

4/ Harrington, D., and East, J. H., Jr., Safe Practices in Mine Hoisting: Bureau of Mines Miners Circ. 61, 1946, table 2.

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Permission to install the model man cage was requested from the Pennsylvania Department of Mines, and after an investigation by a committee of three inspectors the request was granted.

ACKNOWLEDGMENT

The authors wish to express their gratitude to the officials of the Heidelberg Coal Co. for their assistance in obtaining this information and permission to use it. Special acknowledgment is given to John McDade, general manager, and Joseph McDade, superintendent.

INSTALLATION OF THE MODEL MAN CAGE

The installation was started March 27, 1944, but, owing to delay in obtaining the necessary steel, the cage was not completed until December 1, 1945.

Shaft

The elevator shaft is 9 feet square and 110 feet deep and is concreted to the solid sandstone, which was found at a depth of 55 feet. The shaft was extended 14 feet above the surface with concrete blocks to support the hoisting units; a pent house over the shaft encloses the control panel, electric motor, governor, traction wheels, and electric brake.

Figure 2 gives a sectional view of the shaft and the penthouse, and figure 3 shows the structural steel and the guides within the shaft.

Guides

The guides are milled, steel, T-shaped angles held by fish-plated tongue-and-groove joints and securely fastened to the structural steel and the walls of the shaft.

Ropes

Two traction-type grooved sheaves are provided for the hoisting cables.

The four 1/2-inch steel-wire cables used to support the cage have a tensile strength of approximately 14,000 pounds each, and each cable is fastened to the cage independently in a manner to equalize the load carried by each cable. Figure 4 shows how the cables are connected to the cage.

Cage

The cage frame is constructed of steel channels, and the sides and one end are completely enclosed with sheet steel. The end facing the man doors in the shaft is equipped with a folding door. The floor is of wood. Figure 5 shows the cage at the surface landing. The inside dimensions of the cage are 4 by 7 by 7 feet and it has a rated capacity of 2,000 pounds, but only five men and the operator are permitted to ride at one time. The cage travels at the rate of 100 feet a minute. The cage rests on bumper springs when at the lowest landing. An escape hatch is provided in the top of the cage, as shown in figure 6.

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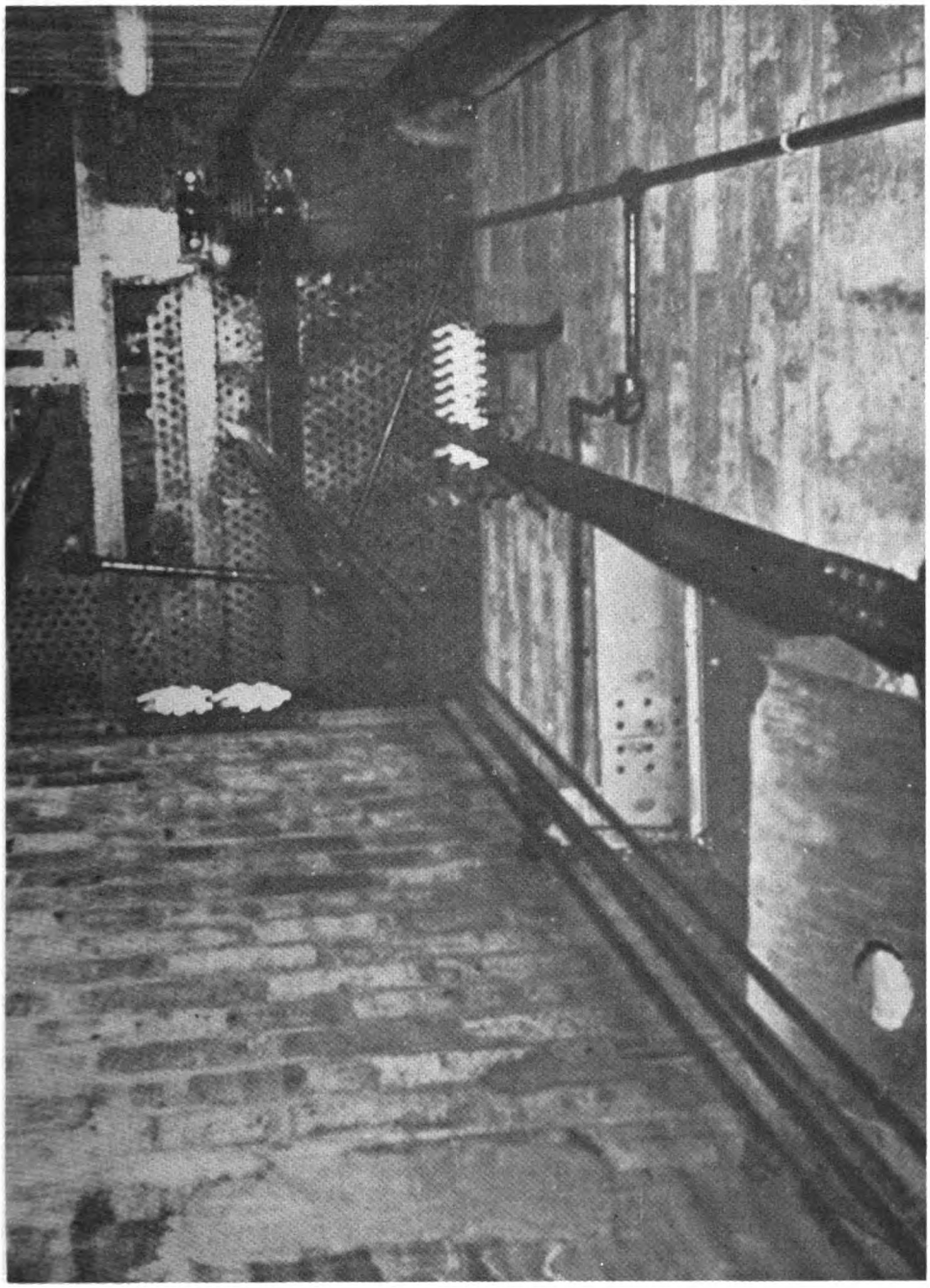

Figure 1. - Shaft extended with concrete blocks and the guides.

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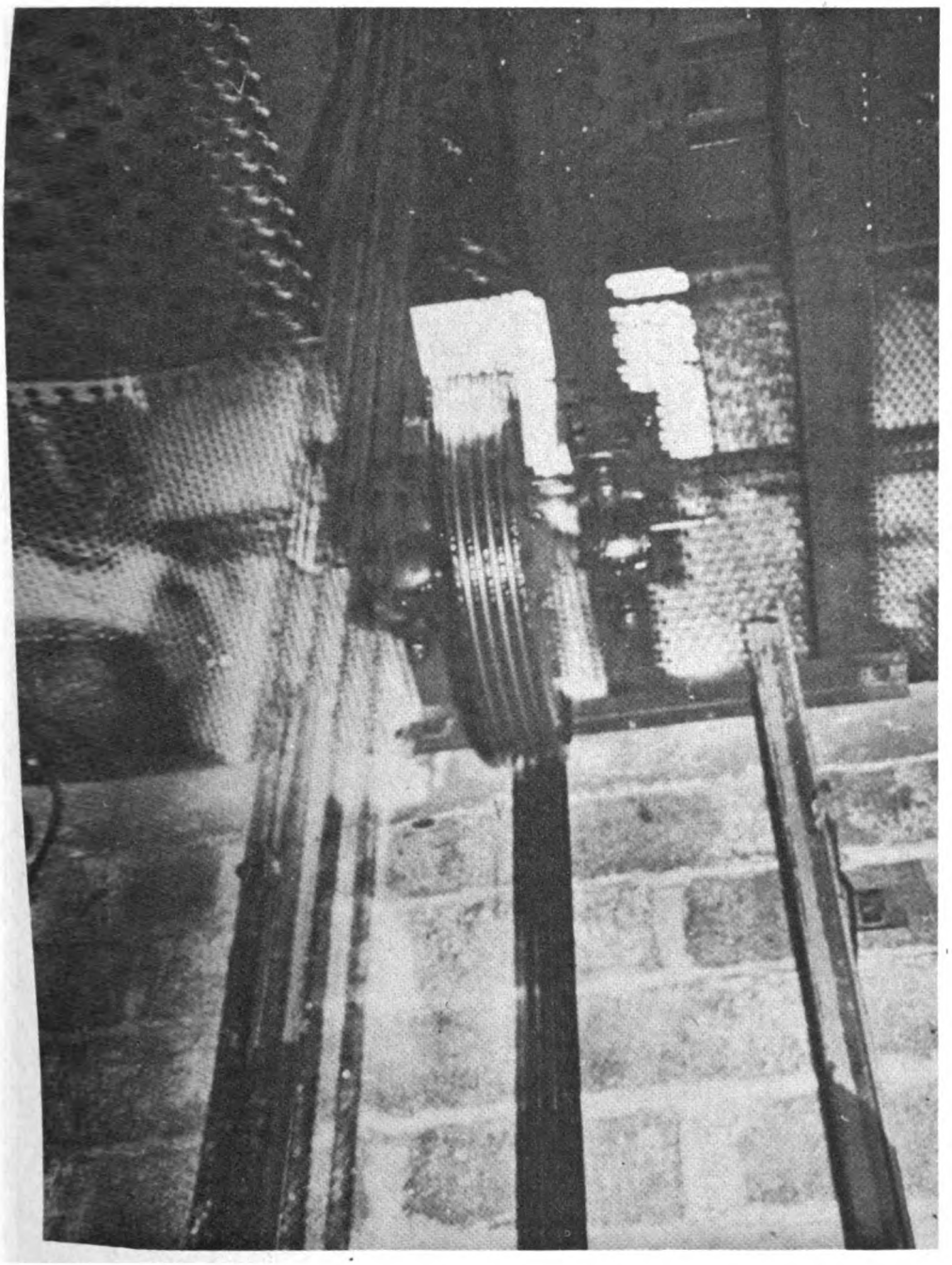

Figure 1A. - Close-up view of the traction wheel on top of the shaft extension.

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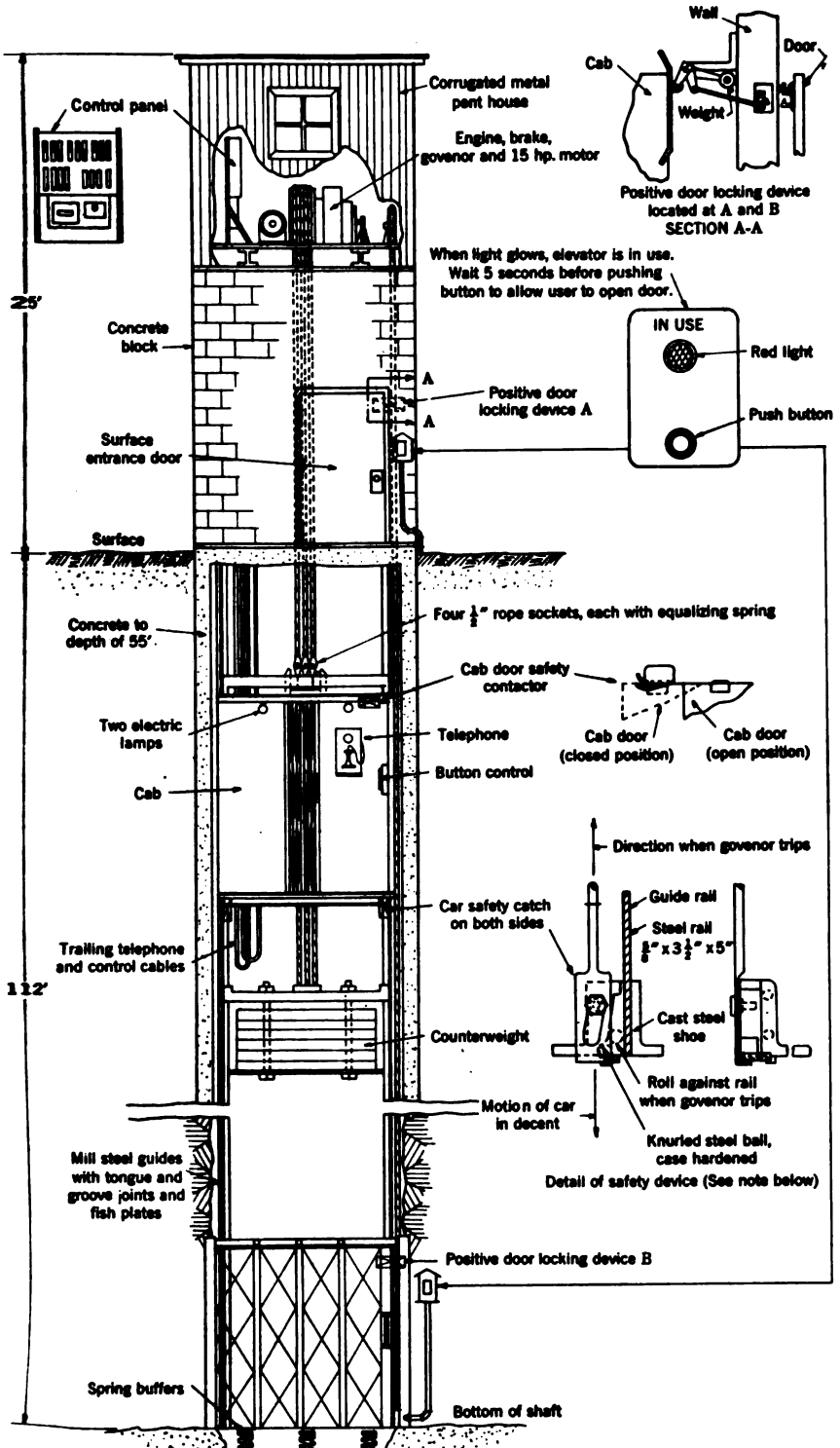

Note: The safety device consists of a cast steel block, a case-hardened knurled-steel roller, and a trip rod. The cast steel block is placed on the bottom crosshead at each side of the car. In the event of the car traveling at excessive descending speed or in the event of the cables breaking; the speed governor will trip and raise the safety rod on each side of the car. When the safety rod raises the case hardened steel roll is brought up the incline of the safety block until it comes in contact with the rail. The descent of the car will then cause the steel roll to wedge in between the block and the rail bringing the car to an instantaneous stop.

Figure 2. - Section view of the shaft, cage, and controls.

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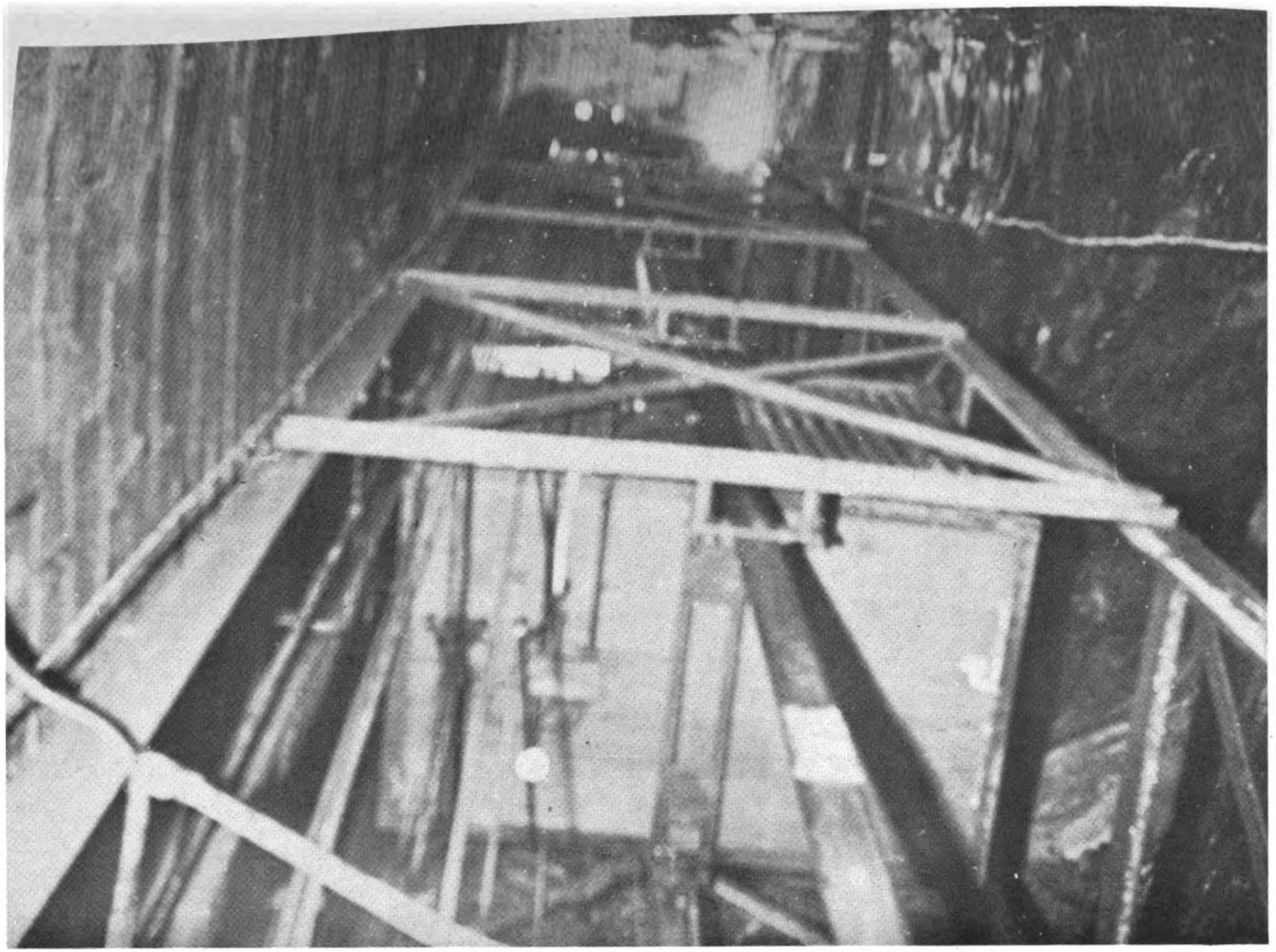

Figure 3. - The structural steel in the shaft, the guides, bottom of the cage, and the safety catches. The view is from the bottom of the shaft.

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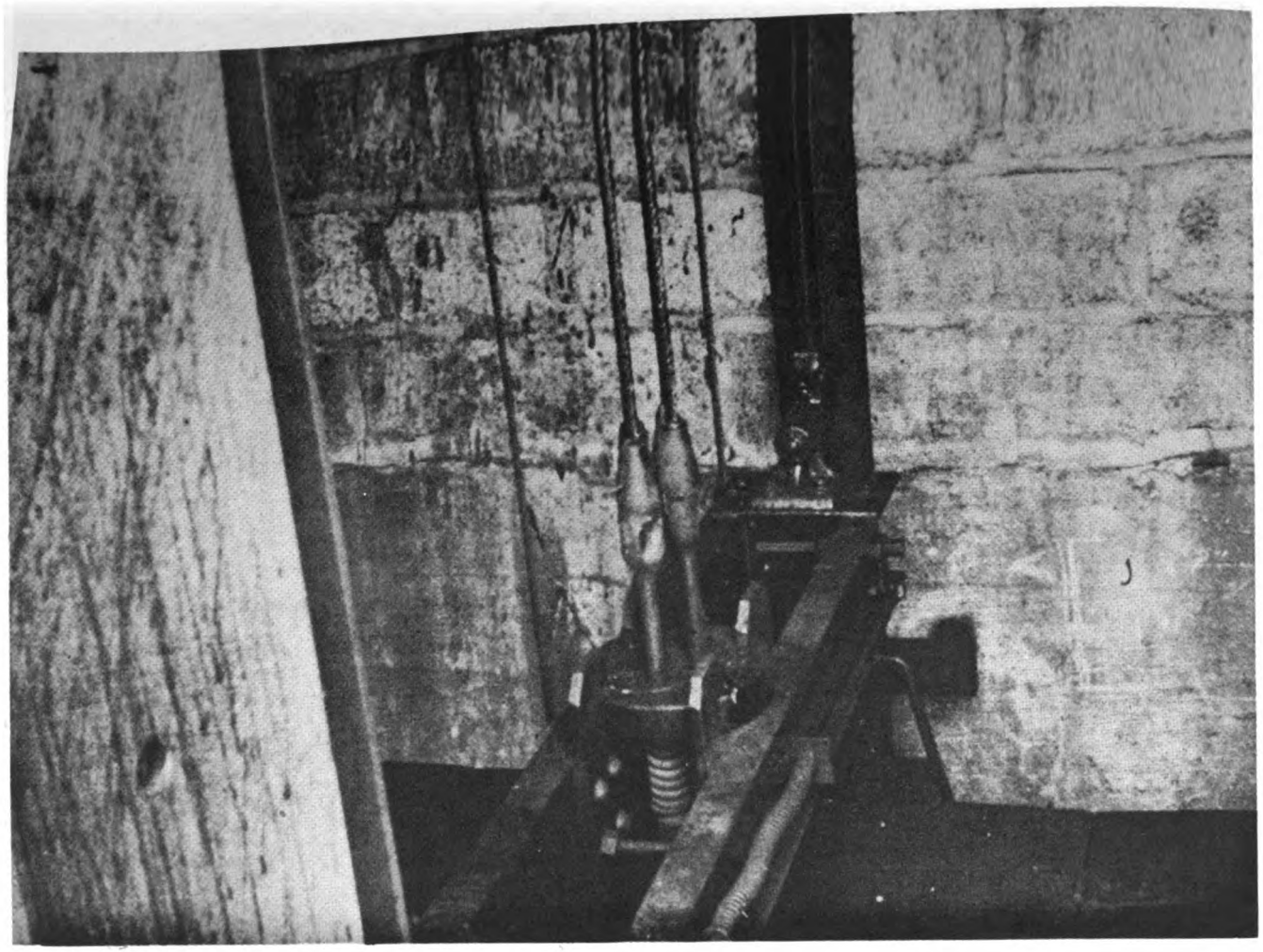

Figure 4. - Rope connections and equalizing springs on top of the cage.

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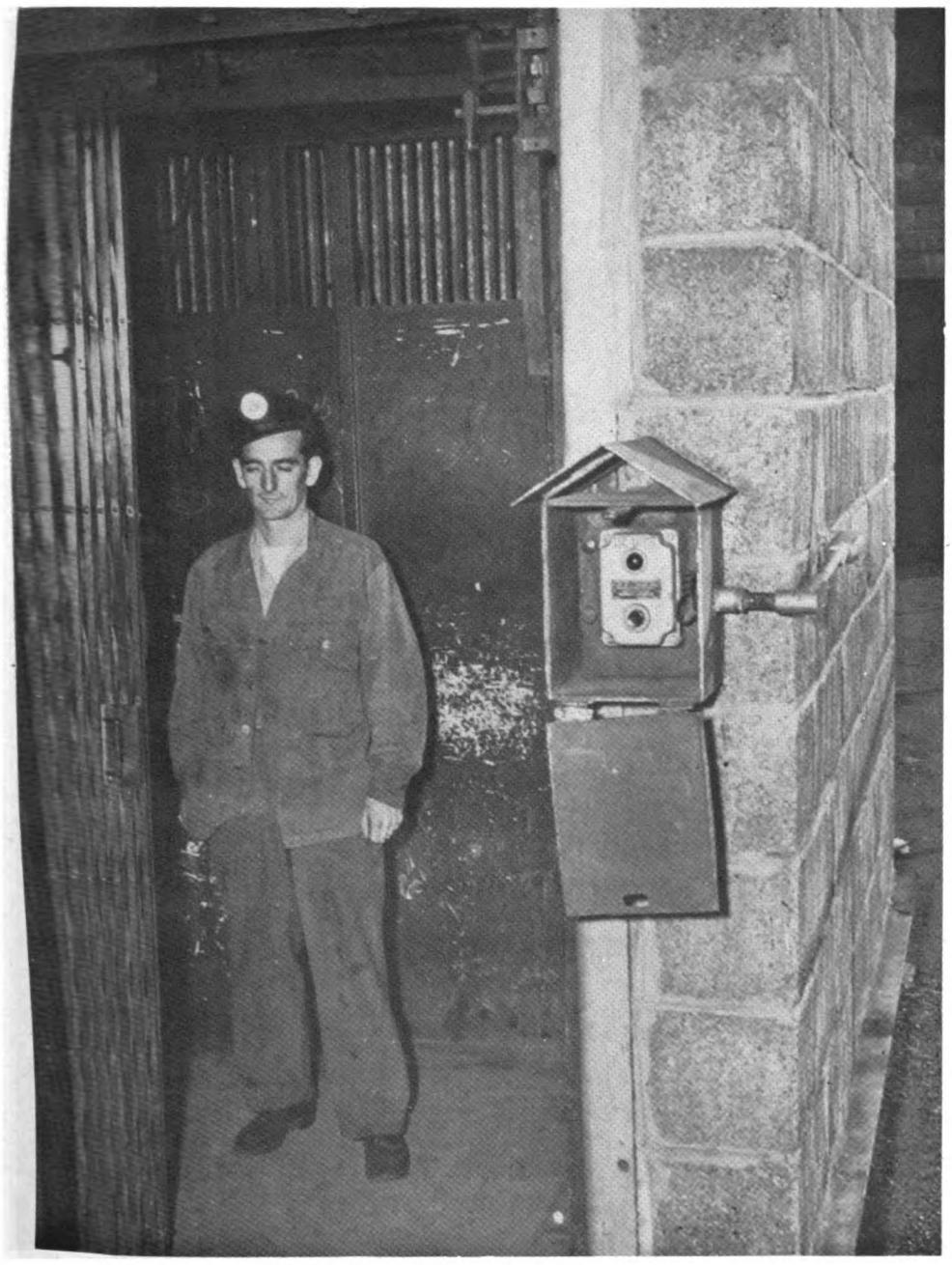

Figure 5. - The cage at the surface landing, the signal glow button, and the folding gate.

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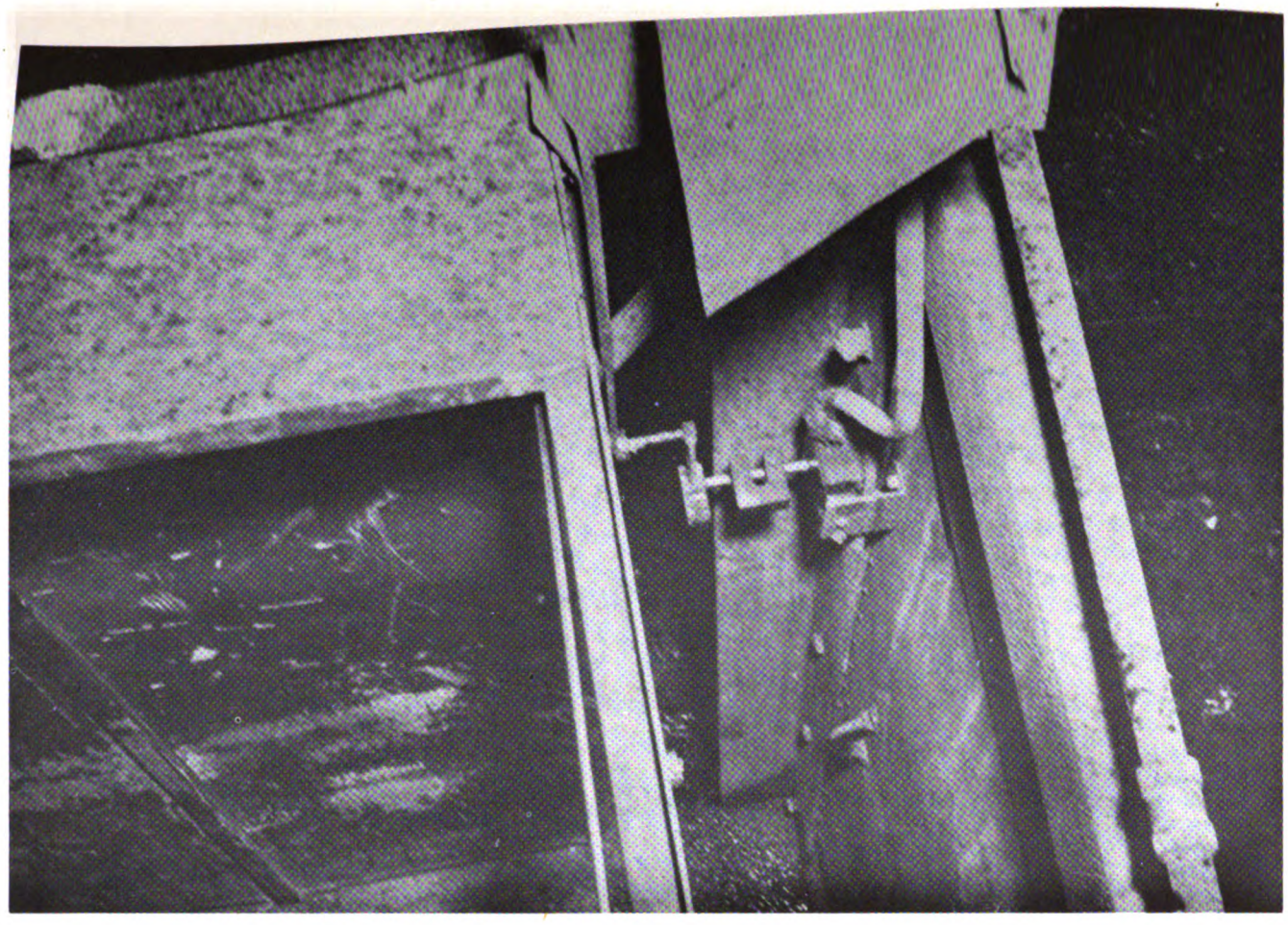

Figure 6. - Escape hatch on the cage and an automatic door-locking device.

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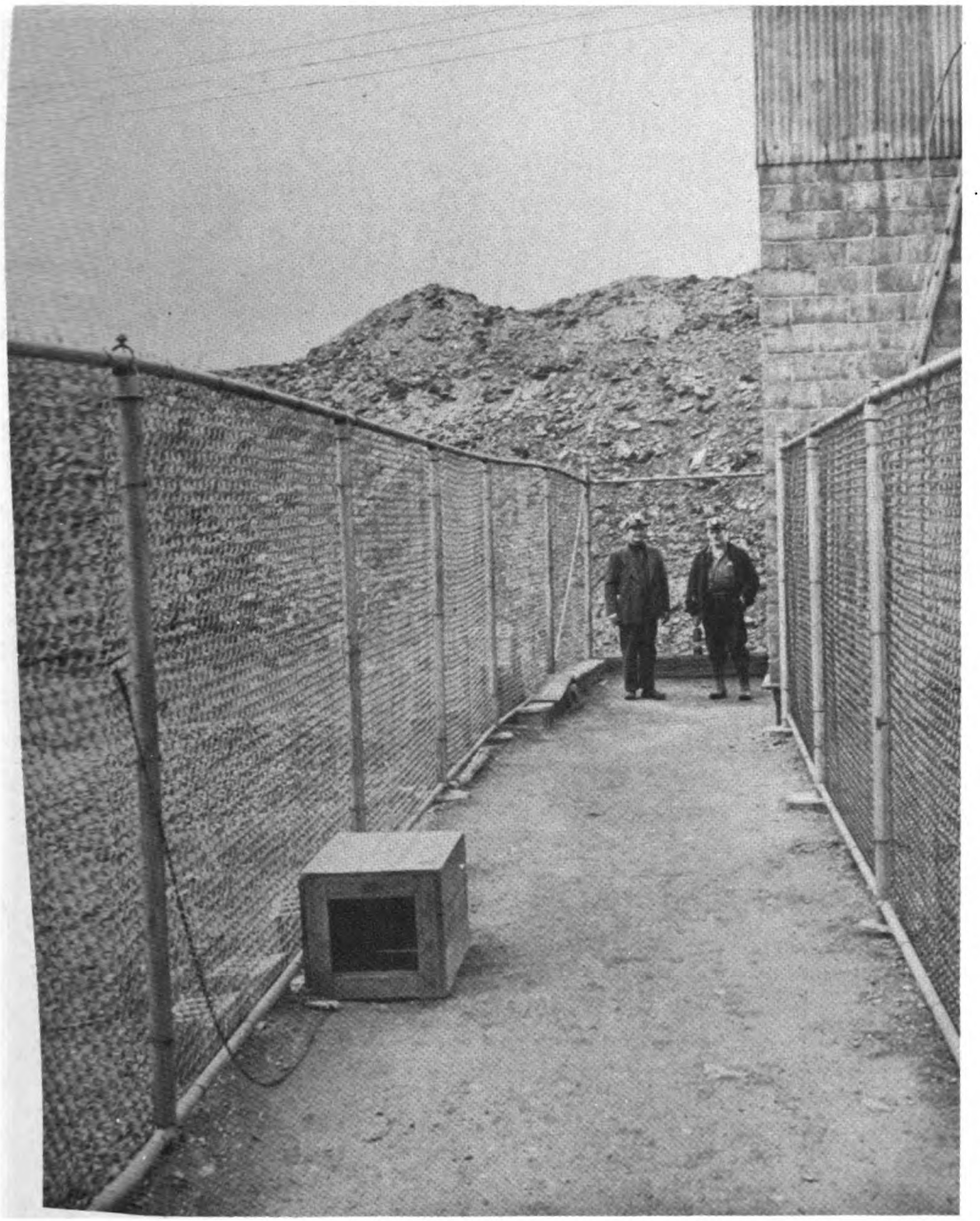

Figure 7. - Walkway to the cage. It is enclosed by a 7-foot cyclone fence.

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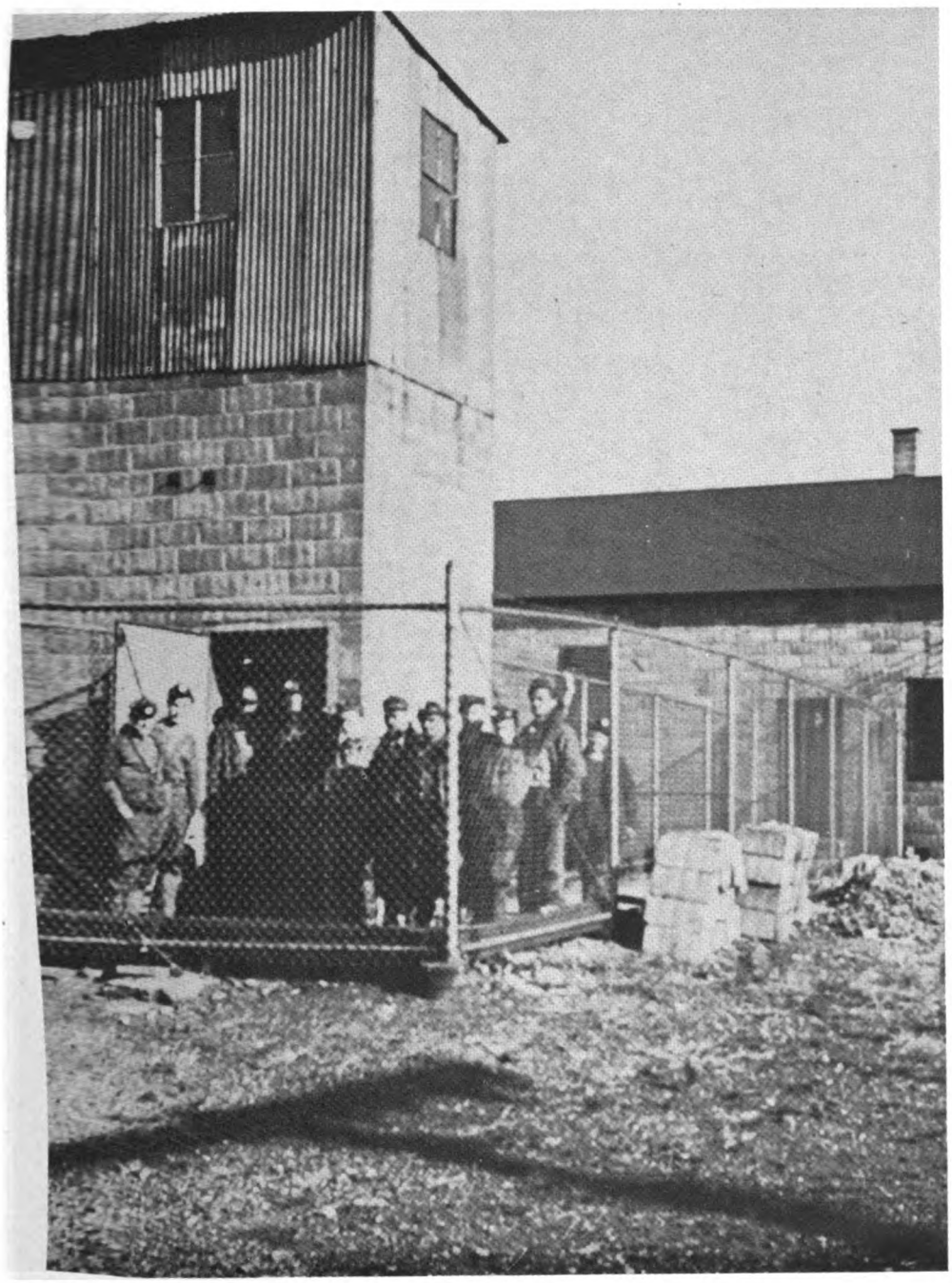

Figure 8. - Workmen about to enter the cage. The lamp house is in the background.

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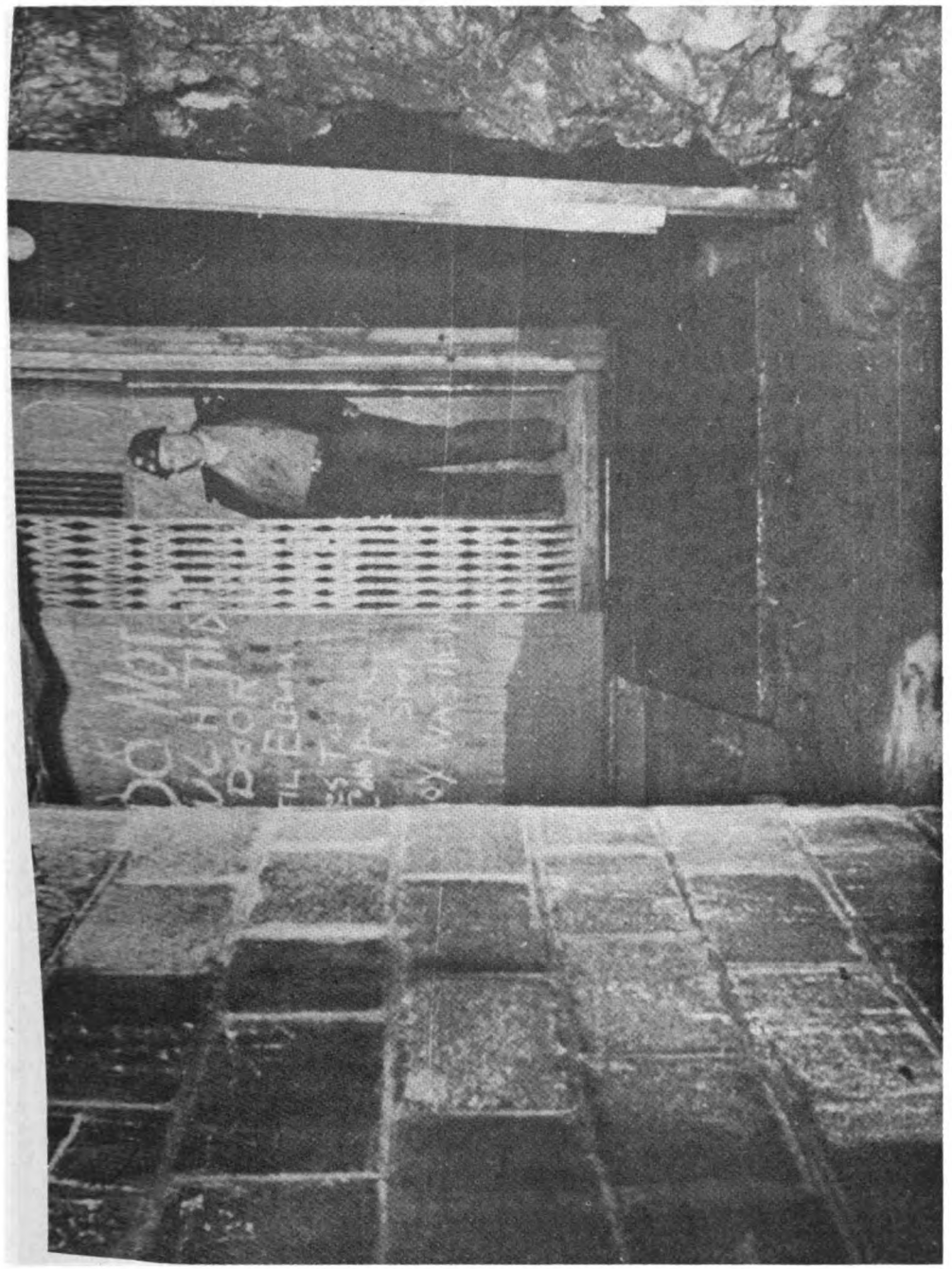

Figure 9. - Cage at the foot of the shaft.

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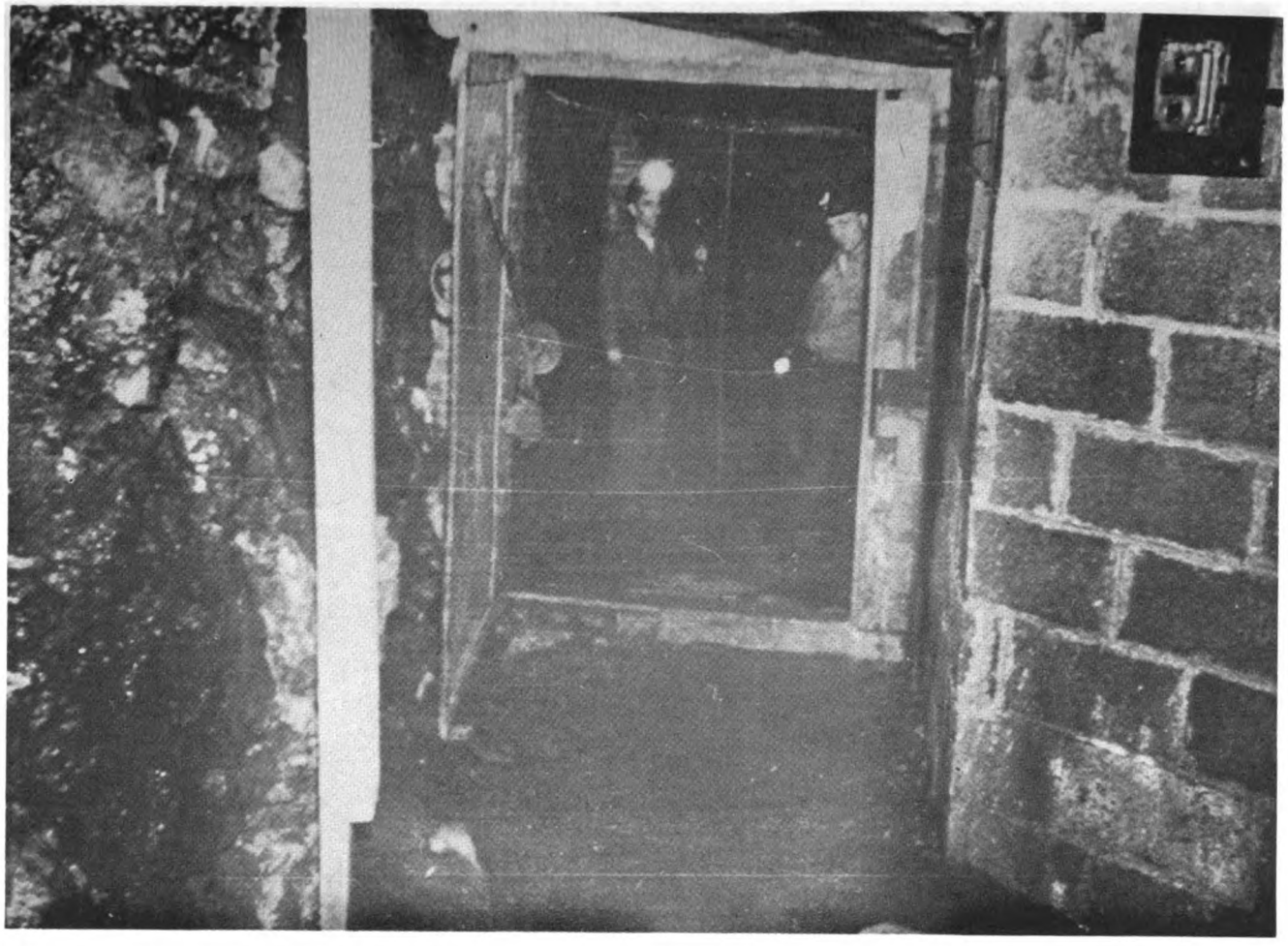

Figure 10. - Air-lock doors leading from the mine to the cage. Note in the upper right corner the signal that glows when the cage is in use.

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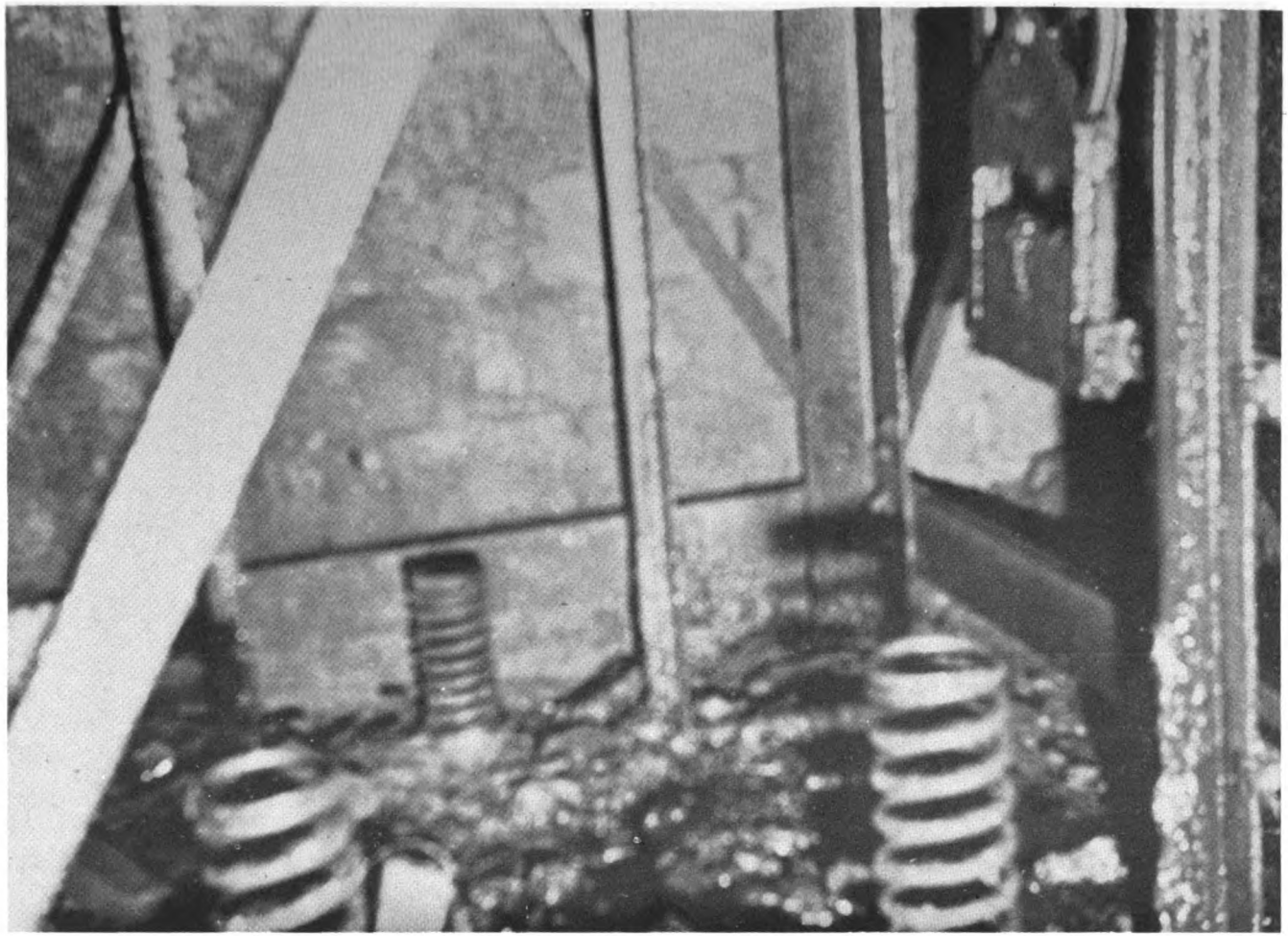

Figure 11. - Spring bumpers for the cage and the counterweight.

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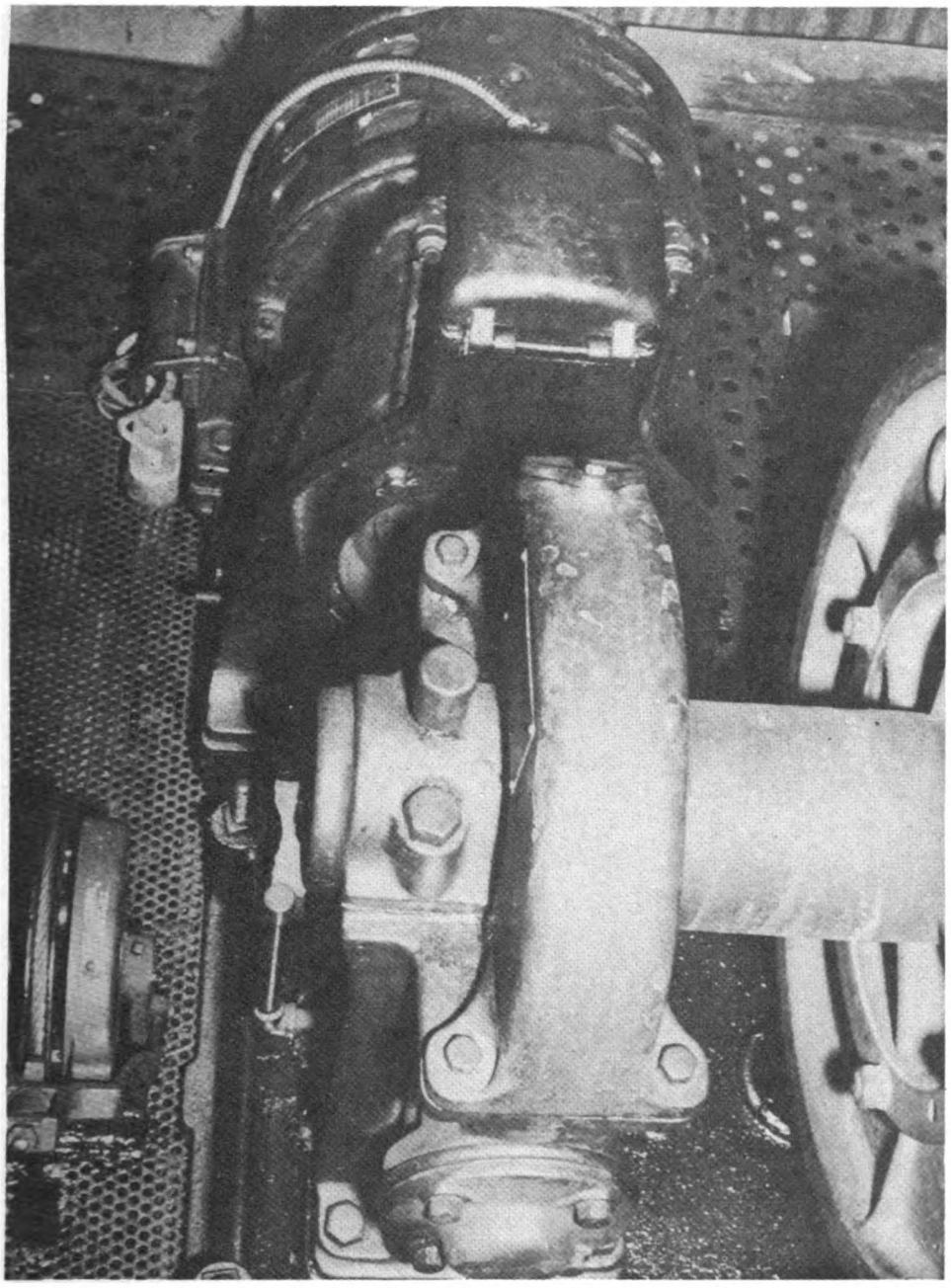

Figure 12. - The 15-horsepower motor used to operate the cage, the enclosed gear for the traction sheave, and the governor.

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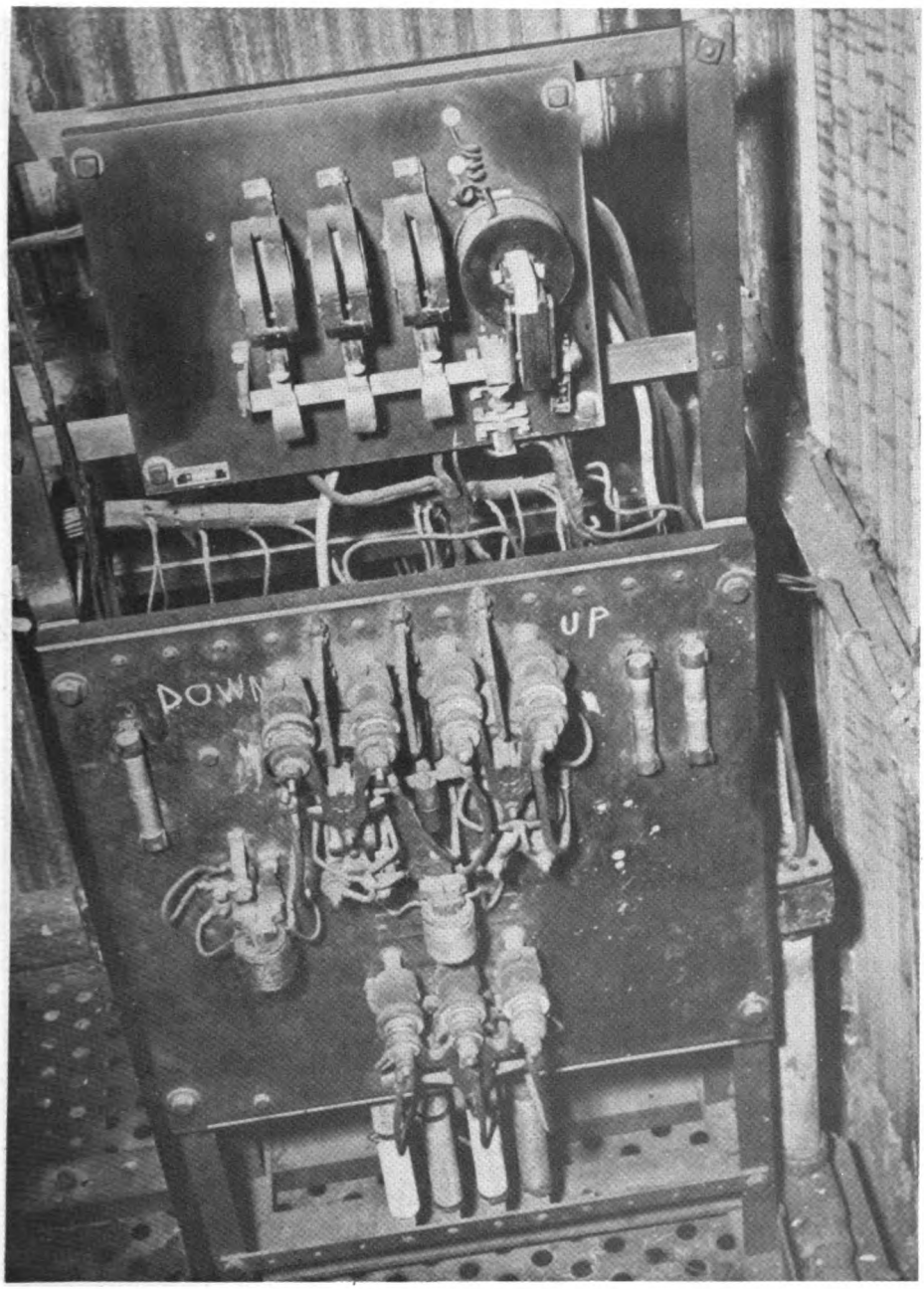

Figure 13. - Panel board and operating controls for the cage.

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Figure 14. - Inside the cage showing the telephone, the UP-DOWN lights, and emergency-stop push-button control.

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Figures 7, 8, 9, and 10 show the surface approach from the lamp house to the cage, men preparing to enter the cage, the cage at the foot of the shaft, and the air locks leading from the mine to the cage.

Electric Cables

Individual cables are provided for the telephone, lights, emergency switch, and control circuit. A junction box is provided in a side wall about midway of the shaft. The cables that extend from the surface to the doors and to the junction box are in conduit.

The trailing cables from the junction box to the bottom of the cage are pairs of No. 16-gage copper wires and a 1/16-inch flexible steel wire, each of which is rubber-covered. The wires of each cable are enclosed in a tough rubber outer jacket, which is waterproof and able to withstand abrasion and hard wear. The trailing cables are anchored to the junction box and to the bottom of the cage by the 1/16-inch wires.

Counterbalance

The counterbalance is metal weights bolted together and supported by the hoisting cables. It is about a third heavier than the empty cage, is guarded at the foot of the shaft, and rests upon spring bumpers when at the bottom, as shown in figure 11.

Operation and Controls

The elevator is of the traction type and cannot be carried above the surface landing, as the counterbalance, when on the spring bumpers in the pit, removes the traction effort at the sheave by virtue of the slack that would be allowed in the ropes.

A 15-horsepower, 220-volt, 3-phase, 60-cycle, alternating-current, squirrel-cage motor is used to operate the cage. Figure 12 shows the motor, the driving unit, and the governor.

The power to operate the electrical equipment is at potentials of 220 and 110 volts alternating current. The push-button controls, cage- and door-locking devices, cage and signal lights, and the limit switch are operated from the 110-volt control circuit. The control circuit terminated at the panel board shown in figure 13. Through a three-pole magnetic contractor and a magnet coil, the 220-volt buses feeding the UP-DOWN reversing switch are energized. The contractors for the motor are equipped with copper and carbon contacts to prevent burning or fusing. Phase, reverse, power failure, and overload relays are installed in the controller circuit.

The push-button controls, the light switch, and the emergency stop controls are within the cage. The contact surfaces in these controls are silver-tipped. Figure 14 shows the controls in the cage and the telephone by which communication can be had with persons either on the surface or underground. Push-button and signal-light controls also are provided at the surface entrance to the cage and at the foot of the shaft, as shown in figure 2. Whenever the cage is in motion,

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a miniature red light glows on the push-button plate, thereby indicating that the cage is in use. The instructions on the plate beneath the light state that the cage is not to be operated for 5 seconds after the light has ceased to glow; this gives the operator of the cage time to unload the passengers before returning to the level where the cage is wanted. The light eliminates annoyance and saves time.

The interlocking devices for the door on the cage and for those at the landings prevent the doors from being opened when the cage is in motion; when the cage comes to rest, the door of the landing at which the cage stops is automatically unlocked. Figures 2 and 15 show the door-locking device at the landings. When the cage is stopped at a landing and the door is opened, the movement of the cam has engaged the roller and opened the latch. The door locks are operated both mechanically and electrically, and before the cage can leave the landing the door must be locked. A switch is provided on the folding door of the cage in such a position that the door must be closed before the cage can be operated.

Brake and Stopping Controls

The brake on the hoisting unit is of the magnet type, and power must be applied before it will release. When the electric motor is energized for hoisting, the brake is also energized, and when the electric current is cut off the hoisting motor, it is likewise cut off the brake, and this automatically applies the brake and stops the cage. A limit switch on top of the cage (fig. 16) stops the cage at the terminal landings independently of the operator. A governor is provided for the cage, and in case of overspeed or rope failure the governor shuts off the power and applies the safety catches under the cage. Figure 2 is a detailed view of the safety catches, and figure 17 shows the rope from the governor and the arm that operates the safety catches.

CONCLUSIONS

The model man cage installed by the Heidelberg Coal Co. demonstrates how safe transportation has been provided for workmen in this shaft. The outstanding safety features are as follows:

1. The cage cannot be overwound.

2. The cage stops automatically at each landing.

3. The doors leading to the shaft cannot be opened except when the cage is at the level of the door.

4. An operator is provided for the cage.

5. A telephone and electric lights are provided on the cage.

6. Overspeed stop controls and safety catches are provided.

7. The possibility of falling from the cage is virtually nil.

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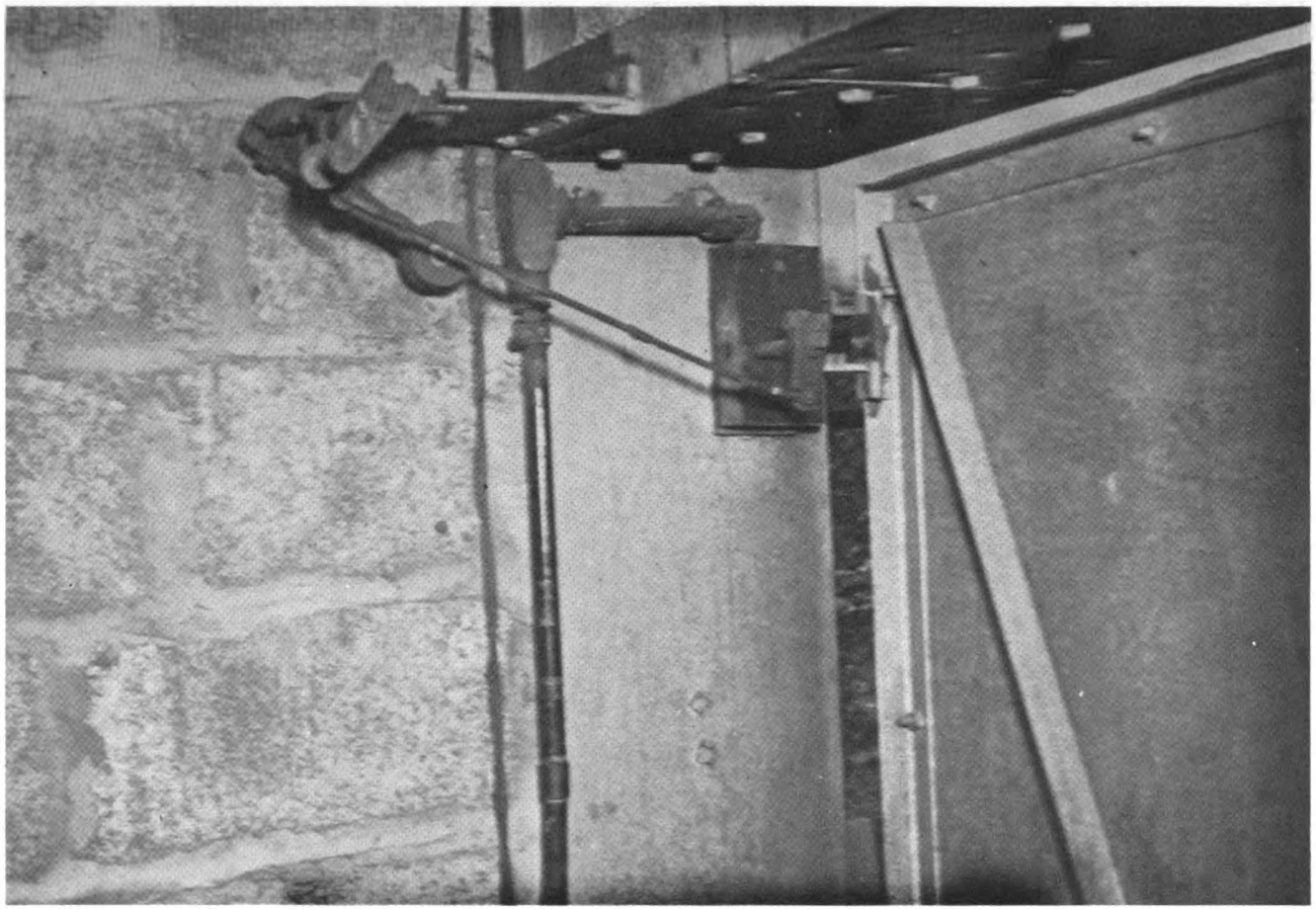

Figure 15. - Shaft-door locking device.

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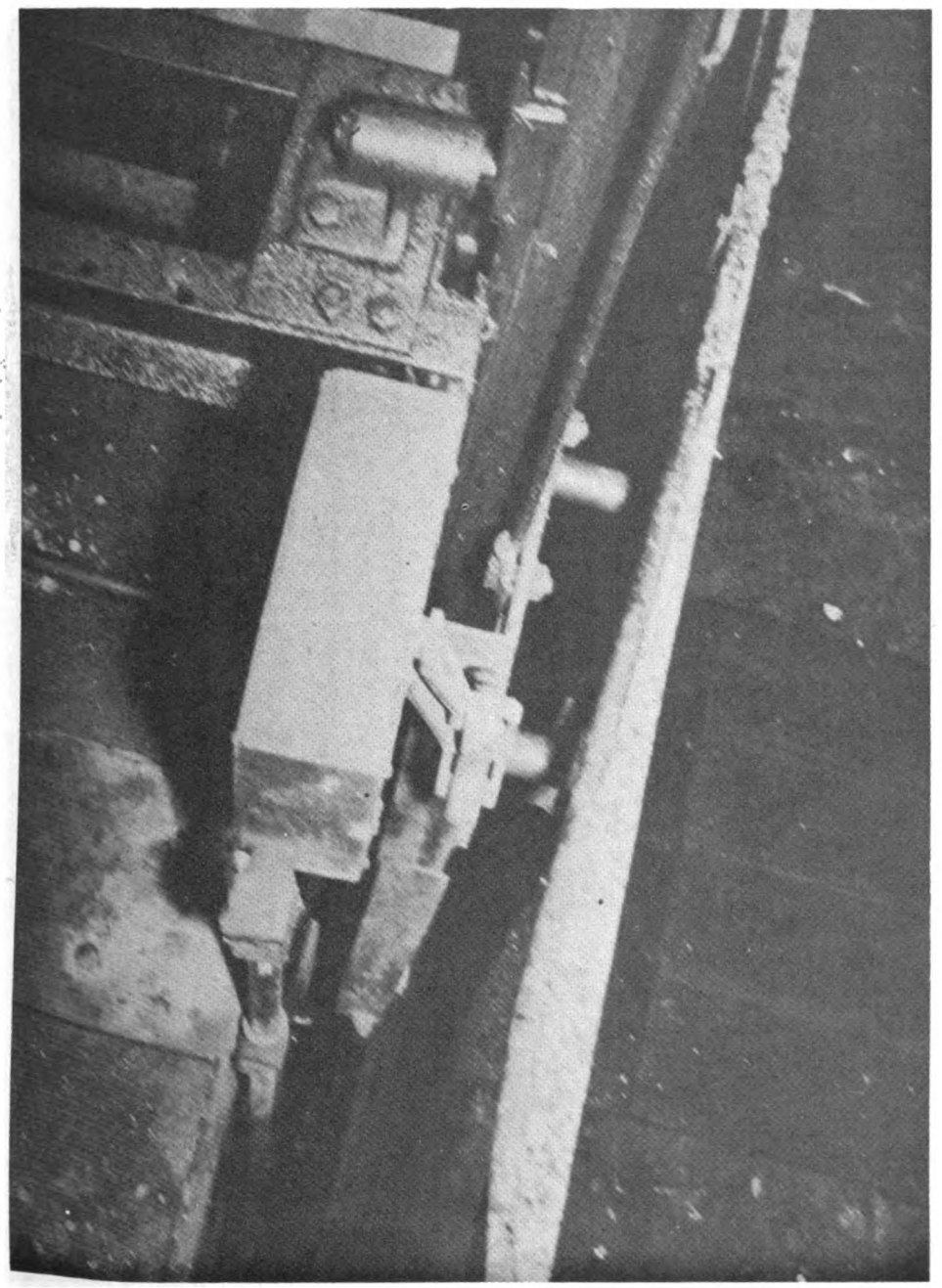

Figure 16. - Automatic limit switch mounted on top of man cage. This switch cuts the power off the cage at the top of the shaft and at the bottom.

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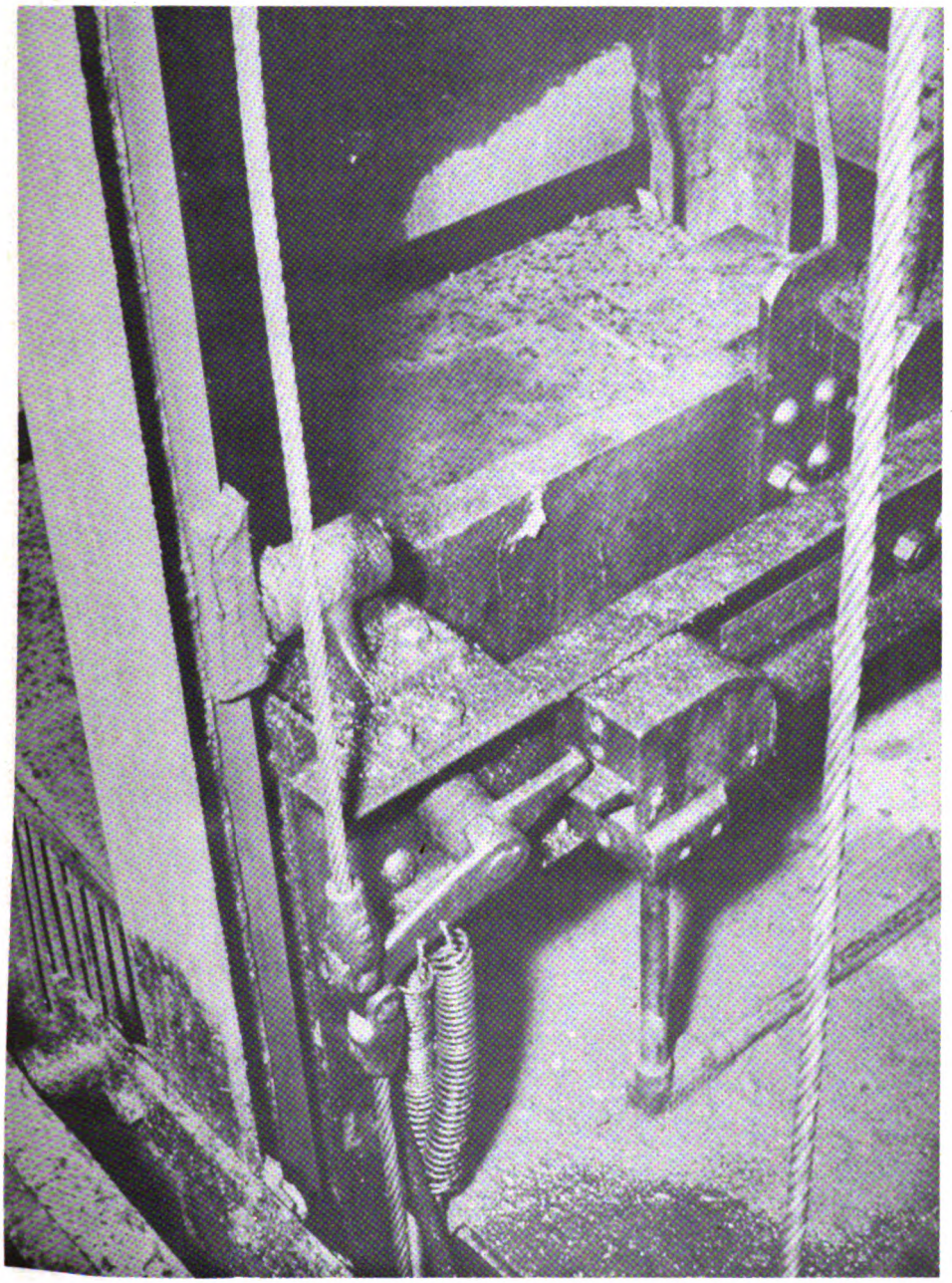

Figure 17. - The rope from the governor, the power cut-off switch, and the arm that operates the safety catches.

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In addition to the many safety features, the cost of installation and operation of the cage should be considered. In installing a cage of this type, the first cost is less, the operating personnel is less, power costs are very much lower, and the cost from shaft accidents should be insignificant, as compared with the usual and conventional methods of transporting men in shafts.

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